Dynamical Studies of Saturn's Rings

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We are currently pursuing several investigations of Saturn's rings, employing data from three Voyager experiments: radio science (RSS), stellar occultation (PPS), and imaging. These investigations, which are concentrated on the poorly-understood but regularly-organized C ring, include a search for eccentric or inclined features; a photometric study of regions of different optical depth; an analysis of wavelike structures at three locations; and a study of the size-distribution of meter-sized particles (with M. Showalter of NASA-Ames Research Center). Recent results from these investigations are summarized here.

a) Eccentric features in the C ring.

Of 35 well-defined features examined in the outer C ring, only 4 show rms deviations from circularity in excess of 2.0 km. These features form the inner and outer edges of two relatively opaque ringlets which lie in, or adjacent to, two narrow gaps at radii of 1.470 R_S and 1.495 R_S (1 R_S = 60,330 km). The 16 km wide 1.470 R_S ringlet, with a radial amplitude of ± 2.2 km, appears to owe its eccentricity to perturbations by the 2:1 inner Lindblad resonance with the satellite Prometheus, although it is possible that the ringlet is freely precessing instead (Porco and Nicholson, 1985).

The 64 km wide ringlet at 1.495 R_S, on the other hand, is almost certainly a freely precessing ellipse, similar to the previously studied Maxwell ringlet (Porco et al., 1984). Its radial amplitude is $\pm$ 3.9 km. These results contradict the expectation that the edges of these two ringlets would be perturbed by two nearby Mimas 3:1 resonances, and call into question the role played by these resonances in forming the surrounding gaps.

(b) Wavelike structures in the C ring.

Much of the fine scale structure in the A ring, and a smaller portion of that in the B ring, has been shown to be due to density waves and bending waves driven at resonances with external satellites (e.g., Holberg 1982; Esposito et al., 1983). Perhaps because of the weaker resonances in this region, no such waves have yet been identified in the C ring. There are, however, three wavelike features associated with narrow gaps at 1.28 R_S, 1.470 R_S, and 1.495 R_S. We have

examined these waves in both the RSS and PPS data, and attempted to fit both density wave models and models describing perturbations by moonlets orbiting within the gaps to the observations.

Rather surprisingly, no model has been found which satisfactorily accounts for either the 1.470 or 1.495 R_s waves, although 14-20 complete oscillations are observed. The wave at 1.28 R_s, with ~15 oscillations, has the characteristics of a density wave, but the associated resonance appears to be far too weak to account for the wave's observed amplitude, Furthermore, the gap associated with the wave, with a width of 15 km, appears only in the RSS occultation data, suggesting either temporal or longitudinal variability, or extreme particle size segregation.

(c) Particle size distributions

We have shown (Showalter and Nicholson, 1986) that the statistical properties of the Voyager PPS stellar occultation data are incompatible with simple photon (i.e., Poisson) statistics. An improved statistical model has been developed, which takes into account the random distribution of finite-sized particles within the rings. When applied to the PPS data, this model yields different, but internally consistent, results for the 4 principal ring regions. For power law size distributions of plausible slopes ($d(\log n)/d(\log r) > -5$), the maximum particle size is found to be $r(max) \leq 3m$ in the C ring, $\leq 5m$ in the Cassini Division, and ~10m throughout the A ring. The B ring shows a gradient in r(max), from ~5m in the inner region to 10-15m in the outermost region. Our results are consistent with average size distributions obtained for the C and A rings by Zebker et al. (1985), based on scattering cross sections at radio wavelengths, but offer the first detailed insight into variations in the size distribution.

References:

Elliot, J.L. and Nicholson. P.D. (1984). In Planetary Rings, R. Greenberg and A. Brahic, Eds., Univ. of Arizona Press.

Esposito, L.W., O'Callaghan, M., and West, R.A. (1983). Icarus 56, 439.

Holberg, J.B. (1982). Astron. J. 87, 1416.

Porco, C.C., and Nicholson, P.D. (1985). BAAS 17, 716.

Porco, C.C., Nicholson, P.D., Borderies, N., Danielson, G.E., Goldreich, P., Holberg, J.B., and Lane, A.L. (1984). Icarus 60, 1.